# SCIENCE FAIR LOGBOOK

# October 21, 2024

Brainstorming for potential research questions using resources like sciencebuddies.

Ideas for research question:

- Thyroid cancer
- Stem cells to create vital organs
- Using synthetic DNA as a secret barcode How Direct Reprogramming Can Transform One Type of Cell Straight into Another

#### SOURCES:

https://www.sciencebuddies.org/science-fair-projects/topic-selectionwizard/recommendations?d=advanced&t=VeryLong&p=4 https://www.sciencebuddies.org/science-fairprojects/project\_ideas/GenEngr\_p013/genetic-engineering/dna-tag-barcode https://www.sciencebuddies.org/science-fair-projects/projectideas/BioMed\_p009/medical-biotechnology/how-direct-reprogramming-can-transformone-type-of-cell-straight-into-another

# October 24 - 25, 2024

Using the ideas above, we are going to change them into questions for our research project.

Research ideas:

- How Can Stem Cells Help to Create Vital Organs and How Else Can They be Used
- How Can Synthetic DNA be Used as a Secret Barcode
- How Direct Reprogramming Can Transform One Type of Cell Straight into Another

# October 28, 2024

Finalizing our question

- Our science fair question is How Can Synthetic DNA be Used as a Secret Barcode
- This will be a research project

# November 20, 2024

#### Starting Background Research about the topic

What is DNA Barcoding?

- DNA barcoding is a method that uses unique genomic DNA that can be used to identify, by PCR, one species from another species.
- Applications include pest and disease control, food production and safety, resource management, biodiversity conservation, and education.

How do Scientists create these barcodes?

- STEP 1 Extracting DNA
  - This would be a small sample tissue of the organism. Some examples are insect leg, hair/feathers, or mouth swab.
  - DNA needed for bulk analysis is extracted from bulk samples of multiple specimens.
- STEP 2 Amplify
  - Scientists use PCR (Polymerase Chain Reaction) to create a lot of copies of a specific region of DNA. Scientists then choose a unique region in the DNA which will be used to distinguish one species from another.
  - PCR is a method used by scientists to create multiple copies of DNA. They are an accurate way to diagnose infectious diseases, some types of cancer, and certain genetic changes.
- STEP 3 Sequence
  - In this stage, scientists feed the DNA into a sequencing machine, where it then translates the DNA into the nucleic acid (A, T, C, and G) sequence that represents its DNA barcode.
- STEP 4 Compare
  - The DNA is then put into the Identification Engine of the Barcode of Life Data System which can be used to compare the DNA barcode made in the last steps to a full library of DNA barcodes to then find a match.
  - This can be very good during a forensic investigation.



#### SOURCES:

https://medlineplus.gov/lab-tests/pcrtests/#:~:text=What%20are%20PCR%20tests%3F,cancer%2C%20and%20certain%20gen etic%20changes.

https://ibol.org/about/dnabarcoding/#:~:text=DNA%20barcoding%20is%20a%20method,library%20to%20provide% 20an%20ID.

#### https://youtu.be/9YGM6L8bzxg

https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.sciencedirect.com%2Fsci ence%2Farticle%2Fpii%2FS1642359318301526&psig=AOvVaw3sXK2ywKPFPLTHSJb9jjnC &ust=1739817102607000&source=images&cd=vfe&opi=89978449&ved=0CBcQjhxqFwoT CKCj2PjpyIsDFQAAAAAdAAAABAY https://lotusarise.com/wp-content/uploads/2023/12/DNA-Barcoding.png https://www.youtube.com/watch?v=zcd3QYngHX0

https://image.jimcdn.com/app/cms/image/transf/dimension=1920x10000:format=jpg/pat h/s6f38401d8dacf420/image/if4ac48e9751f634d/version/1516030302/image.jpg

# December 8, 2024

Presentation on background information and research focus.

https://www.canva.com/design/DAGYwp8IWMM/GqJl3TMTID5sNJb0HbP77g/edit?utm\_co ntent=DAGYwp8IWMM&utm\_campaign=designshare&utm\_medium=link2&utm\_source=s harebutton

March 21<sup>st</sup> update: we have used the presentation and have updated it with our recent research to make our video piece for this project. The original presentation cannot be accessed.

## January 27, 2025

Looking into DNA Barcode Applications and starting to think about other applications:

Previous Applications:

- Cancer Identification
  - Taking the DNA in the infected cells and running it through DNA barcoding technology to record and identify the type of cancer.
- Toxicology
  - By taking small samples of the organism and seeing what type of poisoning has been done to that organism by cross referencing it with DNA of other organisms with similar effects.
- Forensics (Toxicology, entomology)
  - With DNA barcoding, forensic scientist can find DNA traces and be able to find out what it is such as traded drugs, toxins, and insects that might be invasive
- Avian Diet Analysis
  - Scientists can use bird droppings as a way of understanding what the bird eats, which allows for the scientists to create a barcode that shows the bird's diet. This is called DNA metabarcoding, which allows for scientists to identify what the bird eats without having to identify parts of an animal and plant to have a full comprehension of the bird's diet.

- Developmental lineage
  - Scientists can assign a DNA barcode to each cell, which allows them to trace and understand how those cells grow and divide, as well as how they change over time. This also allows for scientists to develop a "map", where they can see how one cell can help to create diverse cell populations over time.

#### SOURCES:

https://pmc.ncbi.nlm.nih.gov/articles/PMC9837303/#:~:text=Barcoding%20has%20had% 20a%20significant,existing%20libraries%20of%20barcoded%20cells.

https://www.sciencedirect.com/science/article/abs/pii/S1752928X21000111#:~:text=Spe cies%20identification%20by%20DNA%20barcoding,and%20monitoring%20of%20traded %20timbers.&text=Contamination%20from%20human%20and%20microbial,their%20dist ribution%20across%20the%20taxa.

https://avianres.biomedcentral.com/articles/10.1186/s40657-021-00276-3

https://pmc.ncbi.nlm.nih.gov/articles/PMC8524429/#:~:text=DNA%20barcoding%20com bined%20with%20sequencing,their%20origin%2C%20development%20and%20differenti ation.

#### January 31, 2025

Creating a brief description of our science fair project.

- In this project, our main goal is to take a deep dive into the ongoing research around DNA barcoding and its uses. From this project, we would love to learn about how DNA barcoding works, its applications, as well as brainstorm potential applications that could be used with potential aid of future technologies and research. Overall, this project aims towards collecting knowledge about DNA barcoding, as well as presenting our findings to others so they may also learn about what we have discovered.
- This project aims to explore DNA barcoding research, its functions, applications, and potential future applications. It seeks to collect knowledge and share findings with others, fostering understanding and potential applications in future technologies.

# February 9, 2025

Looking more into how DNA's acid sequence is used to create a barcode

• Once the DNA has been processed, it comes up as a graph, when then scientist use that graph to understand the composition of the DNA.



- After that, scientists have the list of acids in the DNA, which they can then use to create a barcode
  - Colored Barcode
    - Uses colors to represent the different acids that makes up the DNA



Difference between DNA barcoding and metabarcoding

• DNA barcoding is identifying a single species from a sample, while metabarcoding looks at a species entirely from a mixed sample.

• DNA barcoding is like how a fingerprint can identify a single person or how a grocery scanner can identify a product from its barcode



## SOURCES:

https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.researchgate.net%2Fpubli cation%2F260913341\_Next-generation\_DNA\_barcoding\_Using\_next-

https://www.researchgate.net/publication/260913341\_Next-

generation\_DNA\_barcoding\_Using\_next-

generation\_sequencing\_to\_enhance\_and\_accelerate\_DNA\_barcode\_capture\_from\_single \_specimens

https://www.researchgate.net/publication/5524355/figure/fig1/AS:213907068198912@14 28010827203/Examples-of-DNA-barcodes-distinguishing-sister-species-Neighbor-joiningtree-constructed.png

"Timor-Leste\_Report\_AppendixJ." Unknown , 9 Feb. 2025.

https://www.coris.noaa.gov/activities/projects/timor-leste/docs/Timor-Leste\_Report\_AppendixJ.pdf#:~:text=DNA%20barcodes%20are%20short%2C%20species %20specific%20genetic,black%20stripes%20of%20the%20Universal%20Product%20Cod e.&text=DNA%20metabarcoding%20is%20a%20cutting%2Dedge%20molecular%20techn ique,and%20obtains%20short%20genetic%20sequences%20for%20identification. https://upload.wikimedia.org/wikipedia/commons/thumb/e/ee/DNA\_%28meta%29barco ding\_differences.pdf/page1-440px-DNA\_%28meta%29barcoding\_differences.pdf.jpg

# February 16 - 17, 2025

#### Looking at potential future ideas for DNA barcoding

Security (Identity Check, Passports, International, etc.)

- In the piece of ID there will be a barcode that is made from a person's DNA.
- For example, when a person is pulled over by a police officer, they need to check the person's driver's license and insurance. When checking the license, they could get a sample of their hair and make sure the person with the license rightfully owns the license.
- This is not exactly possible now because it takes proper lab equipment to match DNA samples, and an easier solution is fingerprinting.

Tracking a virus:

- Although a virus is considered non-living (a lot of debate about this), but DNA barcoding can be used to look at its viral genome.
- By taking samples from fomites (contaminated surfaces), scientists can possibly trace the actions of a person who is spreading the disease and understand their movements
- This might require DNA metabarcoding because there will probably be many other bacteria and pathogens on the surface

# February 17, 2025

#### Current Projects using DNA barcoding

#### **Fighting Malaria**

• An organization called Target Malaria has their project working in 5 countries in Africa: Mali, Ghana, Cape Verde, Burkina Faso, and Uganda

- They track the interactions in the area and put them into an "ecological community' and this helps to see the interactions between insects, who are eating them and their interactions with their environment.
- They also created their own DNA barcode library to track the insects in the local area.
- By looking at gut and feces, scientists are able to understand the food chain by using metabarcoding.
- By collecting this data, they are able to look at the food cycle within their community and look at potential solutions to fighting malaria.

#### Assessing Biodiversity Levels

- A project that International Barcode of Life (iBOL) is doing is looking at the biodiversity rates in a British Columbia Logging area
  - This is unique because it is in the wilderness, but it is still considered an urban area because of the amount of people and products that move in that area.
- The wood bark that goes into the ocean from these logs has an effect in the area because it may take away the oxygen and affect what animals live in the area
- By using DNA barcoding and metabarcoding, these scientists are able to track the species in the area and see changes in the population and the food chains.

#### SOURCES:

https://www.youtube.com/watch?v=oEwrtVADfxM

https://www.youtube.com/watch?v=nHOdg0VrdPQ

# February 20, 2025

#### Researching ways synthetic DNA barcoding is being used

Applied Food Technologies:

- Applied Food Technologies company uses DNA barcoding to check if seafood products are correctly labeled.
- They help stop food fraud. For example, if a store sells cheap fish but labels it as expensive salmon, AFT can test the DNA to catch the fraud.
- large companies want to pay AFT to ensure that their products are being labeled correctly and prevent from facing fines, bans or lawsuits.

- if any large company like North Sea Fish and Farms pays AFT to check their products, it is likely that AFT might hesitate to report fraud.
- If AFT relies on seafood companies for business, there could be pressure to protect those companies rather than report negative findings. Their customers are solely just seafood companies and if they fail to make their clients happy, then companies will not rely on AFT for food verification.
- Some critics worry that AFT could adjust results or avoid investigating certain companies to keep their clients happy.

#### Applied Food Technologies

Applied Food Technologies - Alchetron, the free social encyclopedia

EDNA (this company uses metabarcoding, which is not significant to our research, but it was fun to look into 😊 )

- Scientists use DNA barcoding to study what species live in an environment by collecting DNA from soil, water, or air.
- This is important for protecting endangered species and monitoring biodiversity (the variety of life in an ecosystem).
- Problem: DNA in the environment can degrade or mix with other species, making it hard to analyze.
- Degrading DNA means DNA is a fragile molecule that breaks down when exposed to sunlight (UV radiation), heat, water, and bacteria.
- If DNA is too degraded, scientists can't read the full barcode or get accurate results.
- DNA from different organisms can mix together in the environment, making it difficult to tell them apart.
- This is called DNA contamination or cross-species interference.
- Solution: Scientists are working on better ways to collect and analyze DNA, such as improving sample storage and using stronger computer programs to sort through the data.

Environmental DNA (eDNA): Powerful technique for biodiversity conservation -ScienceDirect

https://youtu.be/lxw6QvL1g70?si=SaonpEweCGnMxNLF



**Colossal Biosciences** 

- Colossal Biosciences is a biotechnology company working on bringing back extinct species, like the woolly mammoth, using advanced genetic technology.

- also using synthetic DNA barcoding to help with conservation and biodiversity studies.

- use barcode multiplexing. This allows scientists to track multiple genetic markers at the same time, making it easier to study ecosystems and analyze DNA in forensic research.

challenges:

- DNA degradation. Synthetic DNA can break down over time when exposed to heat, moisture, or UV light, which makes it unreliable for long-term use.

- data errors-misidentification and contamination can make it difficult to tell different DNA samples apart, leading to inaccurate results.

- To solve these problems, scientists are working on two key solutions.

- using protective coatings to shield synthetic DNA from environmental damage, helping it last longer.

- setting strict lab protocols to make sure DNA is handled correctly, reducing the chances of errors in sequencing and analysis.

-With these improvements, synthetic DNA barcoding could become a more reliable tool for conservation and species tracking.

The De-extinction Company | Colossal

# March 2, 2025

Discussion for a potential demonstration

- Can protective coatings prevent the degrading of DNA when exposed to heat, UV light, and water?

Materials:

- 1. DNA samples extracted from a known source.
- 2. Protective Coating material
- Silica (commonly used to preserve fragile materials)
- Chitosan (used to preserve food and beverages)
- Gelatin (a simple natural protective material)
- 3. DNA degrading materials
- Distilled water (for soaking DNA)
- UV light source (UV lamp or direct sunlight exposure)
- Heat source (oven or heat lamp)
- 4. Lab Equipment
- PCR machine
- Containers (to store DNA samples)
- Tubes (for other substances)
- If silica, chitosan, or gelatin coatings help DNA survive harsh conditions, this suggests that stronger, more advanced materials with similar protective properties could be used for preserving synthetic DNA barcodes in real-world applications.
  The PCR machine will be used to check if the DNA remains intact or degrades after exposure to these harsh conditions.

#### This idea will not be pursued due to inadequate materials and time.

# March 7, 2025

<u>Pivoting from the demonstration to research instead</u> We will research further on a study from the National Library of medicine similar to the demonstration we had originally planned.

Oligolysine-based coating protects DNA nanostructures from low-salt denaturation and nuclease degradation - PMC

# March 11, 2025

#### Working on slideshow for show-n-tell

What is the difference between DNA Fingerprinting and DNA barcoding?

- DNA fingerprints look is unique patterns in ones DNA that makes people different
  - Humans are nearly 98% 99% genetically identical. When DNA fingerprinting is in process, restriction enzymes look for repeating parts of DNA that don't code for anything, for this part of the DNA make each of use unique. After that, it is put into a PCR machine to amplify the amount of the sample. Next, it is put into an agarose gel, which is like a maze for the DNA strands. Since DNA is negatively charged, it will naturally want to move towards the positive bottom of the agarose gel. Shorter strands of DNA will move faster to the bottom than longer strands, which divides the overall sample into different observable lines. This is what creates a DNA fingerprint.



• On the other hand, DNA barcoding looks at the entire region of the DNA (the lining of the A and T and the G and C) to help identify species and other objects

#### SOURCES:

0

https://infinitylearn.com/surge/wp-content/uploads/2023/09/DNA-Fingerprinting.png https://pubmed.ncbi.nlm.nih.gov/22419485/

Slides removed from slideshow video to reach around 10 min run time. It goes a bit over but no other info can be removed.

# Applications of Synthetic DNA Barcodes

Synthetic DNA barcodes are useful for:

- Stopping fake products in areas like medicine and luxury items.
- Tracking products to confirm they are real.
- Labeling biological samples for easy identification.
- Helping scientists study biodiversity by marking different species clearly.





# Applied Food Technologies

- AFT uses DNA barcoding to check if seafood products are correctly labeled.
- Helps stop food fraud.
- Problem: Some people worry that AFT might be influenced by seafood companies and might not always be neutral
- They are also not always required to share all their testing methods and results.
- Our solution: If AFT had to follow strict, independent regulations, it would be easier to verify that their results are fair.